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(12) **Unexamined Patent Application**

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(54) Process for the regeneration of adsorbers

(57) A process for the regeneration of adsorbers is described, in which the adsorbing material is electrically conductive and is heated using electric current to a temperature at which the adsorbed material is expelled.
The process according to the invention is characterized in that compressed or fibrous activated charcoal is used as adsorbing electrically conductive material, and the current passage is such that the whole volume of the material is uniformly heated.

Description

The invention relates to a process for the regeneration of adsorbers, in which the adsorbing material (adsorbent) is heated to a temperature at which the adsorbed material is expelled, i.e. desorbed.

In recent years adsorbers have found increased use inter alia for the removal of pollutants from water or air. For example, chlorinated hydrocarbons (CHCs) can be removed even in low concentrations by means of adsorbers from fluid flows, such as flows of gas or water. A typical use is the redevelopment of abandoned polluted sites contaminated by CHCs by suction with integrated adsorption of the pollutants. Activated charcoal is often used as adsorber.

As the adsorptive capacity declines somewhat due to the "occupancy" of the adsorber spaces, it is necessary to regenerate the adsorbing material by expelling the adsorbing material. However this regeneration often causes problems:

At present the so-called displacement process using steam is most often used; in this process the regeneration of for example activated charcoal is only partially successful, so that, after several regeneration cycles, the efficiency of the adsorbing material has declined to the point where it must be disposed of at great expense.

W. Kast therefore suggests in his book "Adsorption aus der Gasphase" [Adsorption from the gas phase] (Verlag VCH Weinheim, 1988) the thermal regeneration or the combination of thermal regeneration and the displacement process. To carry out this regeneration process the activated charcoal must however be heated over a heat exchanger. In most cases this means that the activated charcoal has to be removed from the adsorption device before regeneration as, due to its poor heat transfer, a heating of the adsorber column from outside is uneconomical.

Furthermore a process and a device for the regeneration of activated charcoal are known from DE 29 53 672 A1 in which an arc which is generated by a pulsating voltage releases the adsorbed substance. The use of arcs

leads however to pronounced burning-off and thus to a rapid consumption or wear of the adsorber.

Furthermore a process is known from US-PS 42 61 857 in which consumed activated charcoal is poured into a hermetically sealed oven with several electrodes arranged vertically at intervals. An electric current which heats the activated charcoal is passed over the electrodes so that the adsorbed substances are released.

In this process and also that known from US-PS 42 61 857 the activated charcoal must be present in "particle form". The use of powdery or granular activated charcoal has however the disadvantage that both the electric and the heat conduction resistance is high so that the regeneration efficiency is low. In addition, due to the non-uniform charging, hot spots form during the electric heating of particulate, swirlable activated charcoal, which can lead to spontaneous ignition upon subsequent re-use as adsorber.

Moreover it is necessary in the case of the known processes and devices in which the activated charcoal is electrically heated to remove the activated charcoal from the actual adsorption device for the purpose of regeneration.

The object of the invention is to provide a process for the regeneration of adsorbers consisting of activated charcoal which can be carried out without having to remove the adsorbing material from the adsorption device, and which has a high regeneration efficiency without hot spots being able to form.

The achievement of this object, according to the invention, is given in claim 1. Further developments of the invention are the subject-matter of the dependent claims.

This object is achieved according to the invention in that the starting-point is a process for the regeneration of adsorbers in which the adsorbing material (activated charcoal) is heated to a temperature at which the adsorbed material is expelled, i.e. desorbed.

According to the invention an electrically conductive material is used as adsorbing material, the activated charcoal being made uniformly electrically conductive for example by being compressed and sintered as tube, an adequate electrical conductivity being maintained given suitable preparation.

To heat the electrically conductive adsorbing material, it is heated by current passage, such that the adsorbing material is expelled.

The heating can take place by direct current passage (claim 3). Suitable electrodes are provided for this, to which a direct or alternating voltage is applied.

Furthermore it is also possible to heat the electrically conductive adsorbing material inductively with a known induction heating device (claim 4).

Moreover it is however also possible, instead of or in addition to heating by current passage, to carry out the heating of the adsorbing material by a microwave heater by which the whole volume of the material is likewise uniformly heated (claim 5).

In each case the regeneration of the adsorbing material can take place both in the actual adsorption device and outside the adsorption device. In the case of a (as a rule preferred) regeneration of the adsorbing material in the adsorption device it is of course to be ensured that the desorbed pollutants are collected in suitable manner.

The process according to the invention in which a heating of the adsorbing material takes place by current passage and/or microwave heating can be used regardless of the structural form of the adsorber: thus it is possible to use as adsorbers hollow fibres or hollow columns through which the polluted medium flows, or to use mesh-shaped structures.

In the case of the use of activated charcoal as adsorbing material the activated charcoal can easily be prepared in the desired geometric form by coking of suitable structures. There can be used as starting materials e.g. briquettes made from charcoal, extruded pitch or any polymers such as nylon, polyamides, cellulose etc which are present in the desired form and which are heated to the coking temperature with exclusion of air. Upon reaching a specific degree of coking an electrical conductivity results which allows an adequate heating of adsorbers with customary voltages.

In each case it is however an advantage if the pollutants desorbed during the regeneration phase are removed by a carrier-gas stream. The carrier-gas stream can be for example an inert gas (claim 8) or steam (claim 7). When steam is used as carrier gas the thermal regeneration and the displacement regeneration are combined with each other on the one hand and

on the other hand the pollutants are separated particularly easily by condensation. However the direct heating prevents the formation of steam condensate in the pores of the adsorbing material which, with the known displacement regeneration processes, hinders the diffusion of the desorbent pollutant molecules and thus ends the regeneration after a few cycles.

The invention is described in more detail below with reference to the drawing, in which are shown:

Figs. 1 to 4 various embodiments of the invention.

Figs. 1 to 4 show adsorber devices which are designed according to the invention such that they make possible an "in situ" regeneration of the adsorbing material. To this end, the adsorbing material is present in the form of hollow tubes 2 which have been made by a compression or sintering process.

In order to make possible a heating of the adsorbing material for example by direct current passage, suitable electrodes 1' and 1'' are provided in the embodiments shown, to which a direct or alternating voltage is applied. Furthermore it is also possible to heat the electrically conductive adsorbing material 2 inductively with a known induction heating device.

Fig. 1 shows the basic structure of a device in which tubes 2 are used as adsorbing material, while Fig. 2 shows a possibility of the contacting of the tubes 2 by the electrodes 1: By pressing the electrode 1' towards the tubes 2 by means of a spring 3, a particularly small contact resistance results.

Fig. 3 shows an embodiment in which the adsorbing material is present in the form of activated charcoal capillaries 2' into which for example solvent-loaded air enters, which then emerges as solvent-free air. The capillaries 2' are connected by means of a conductive adhesive 4 to a metal ring 5 made of Al, Cu or VA, which serves as electrode.

In every case the regeneration of the adsorbing material 2 can be carried out both in the actual adsorption device and outside the adsorption device. During a regeneration of the adsorbing material in the adsorption device it is of course to be ensured that the desorbed pollutants are collected in suitable way.

This can take place immediately by applying a vacuum with adjacent cooling trap or by inserting a solvent-selective membrane according to Fig. 4

in the embodiment shown which is a solvent-selective polymer film 6 which is applied directly to the tube 2 made of activated charcoal.

The embodiments shown can be easily produced for example by coking a material present in the desired geometric form. There can be used as starting material e.g. briquettes made from charcoal, extruded pitch or any polymers such as nylon, polyamides, cellulose etc, which are present in the desired form and which can be heated to the coking temperature with exclusion of air. Upon reaching a specific degree of coking an electrical conductivity results which allows an adequate heating of adsorbers with customary voltages.

Under certain circumstances it is advantageous if the pollutants desorbed during the regeneration phase are removed by a carrier-gas stream. The carrier-gas stream can be for example an inert gas or steam. When steam is used as carrier gas the thermal regeneration and the displacement regeneration are combined with each other on the one hand and on the other hand the pollutants are separated particularly easily by condensation. However, the direct heating prevents the formation of steam condensate in the pores of the adsorbing material which, with the known displacement regeneration processes, hinders the diffusion of the desorbent pollutant molecules and thus ends the regeneration after a few cycles.

When carrying out the process according to the invention it is furthermore advantageous if two or more adsorber columns are used the adsorbing material of which is electrically conductive. By using at least two adsorber columns the device can be alternately loaded and regenerated by simple switching of one or more columns so that a continuous operation of the adsorption device is possible without changing the adsorber.

Patent claims

1. Process for the regeneration of adsorbers in which the adsorbing material is electrically conductive and is heated using electric current to a temperature at which the adsorbing material is expelled, **characterized in that** compressed or fibrous activated charcoal is used as adsorbent electrically conductive material and that the current passage takes place such that the whole volume of the material is uniformly heated.

2. Process according to claim 1, characterized in that there is used as adsorbing material activated charcoal which is made uniformly electrically conductive by sintering.

3. Process according to claims 1 and 2, characterized in that the adsorbing material is heated by direct current passage.

4. Process according to claims 1 and 2, characterized in that the adsorbing material is inductively heated with an induction heater.

5. Process for the regeneration of adsorbers, in which the adsorbing material is heated to a temperature at which the adsorbing material is expelled, characterized in that compressed or fibrous activated charcoal is used as adsorbing material and the heating takes place by a microwave heater such that the whole volume of the material is uniformly heated.

6. Process according to one of claims 1 to 5, characterized in that the regeneration takes place in the adsorber device.

7. Process according to one of claims 1 to 6, characterized in that steam is used as flushing gas.

8. Process according to one of claims 1 to 7, characterized in that an inert gas is used as flushing gas.

9. Process according to one of claims 1 to 8, characterized in that at least two adsorber columns are used which are alternately loaded with the polluted fluid or regenerated.

10. Device for carrying out the process according to one of claims 1 to 9, characterized in that the adsorbing material is present in the form of tubes or hollow fibres, through which the polluted fluid flows.

11. Device for carrying out the process according to one of claims 1 to 9, characterized in that the adsorbing material is present in the form of mats through which the polluted fluid flows.

12. Device according to claim 10 or 11, characterized in that a solvent-selective membrane is provided in which the desorbed solvent preferably dissolves.

4 pages of drawings

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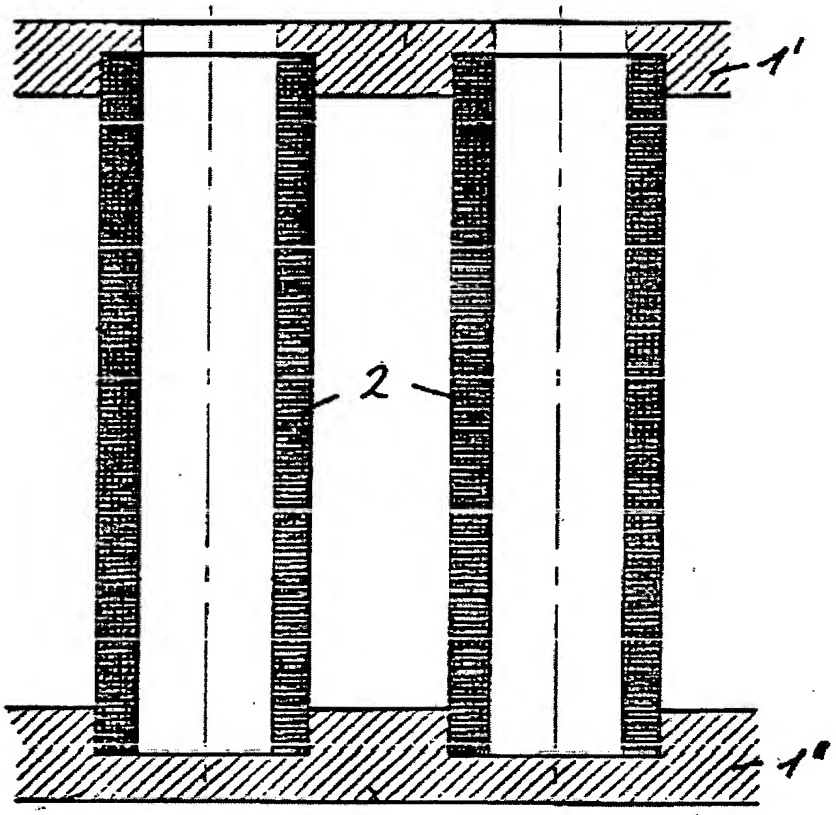

Fig. 1

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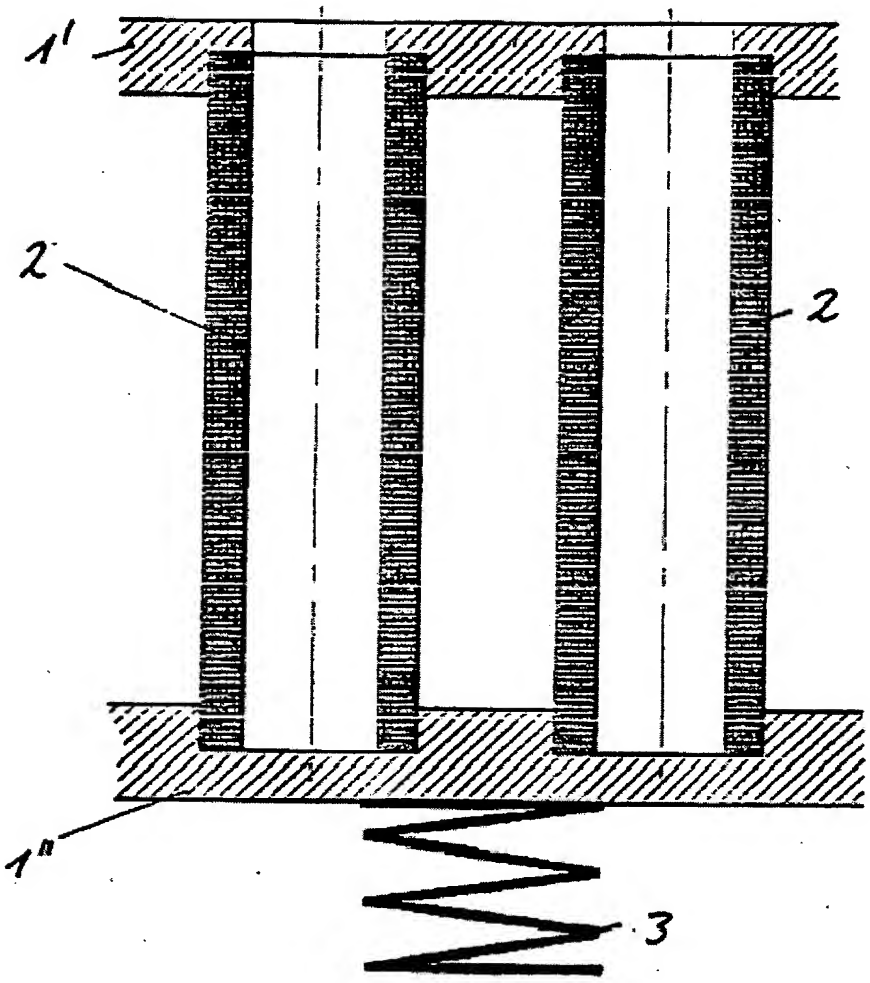

Fig. 2

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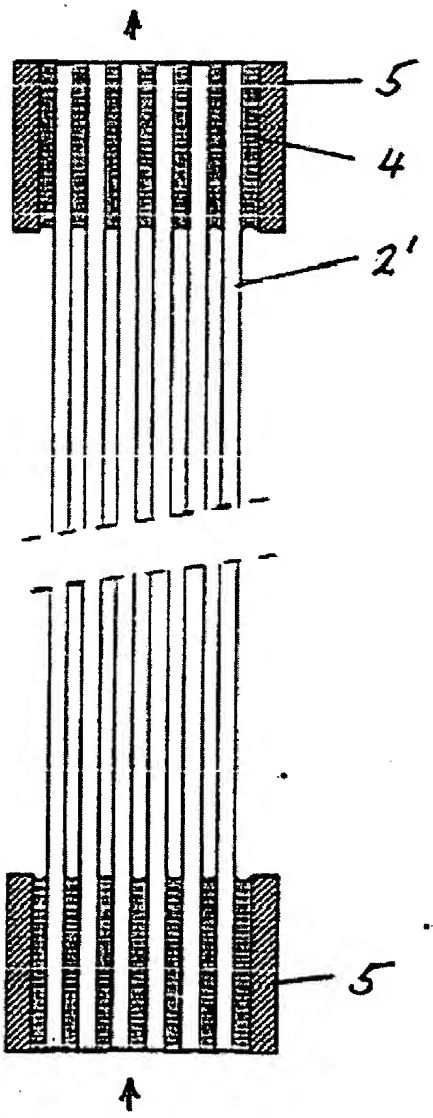
solvent-free air



solvent-loaded air

Fig. 3

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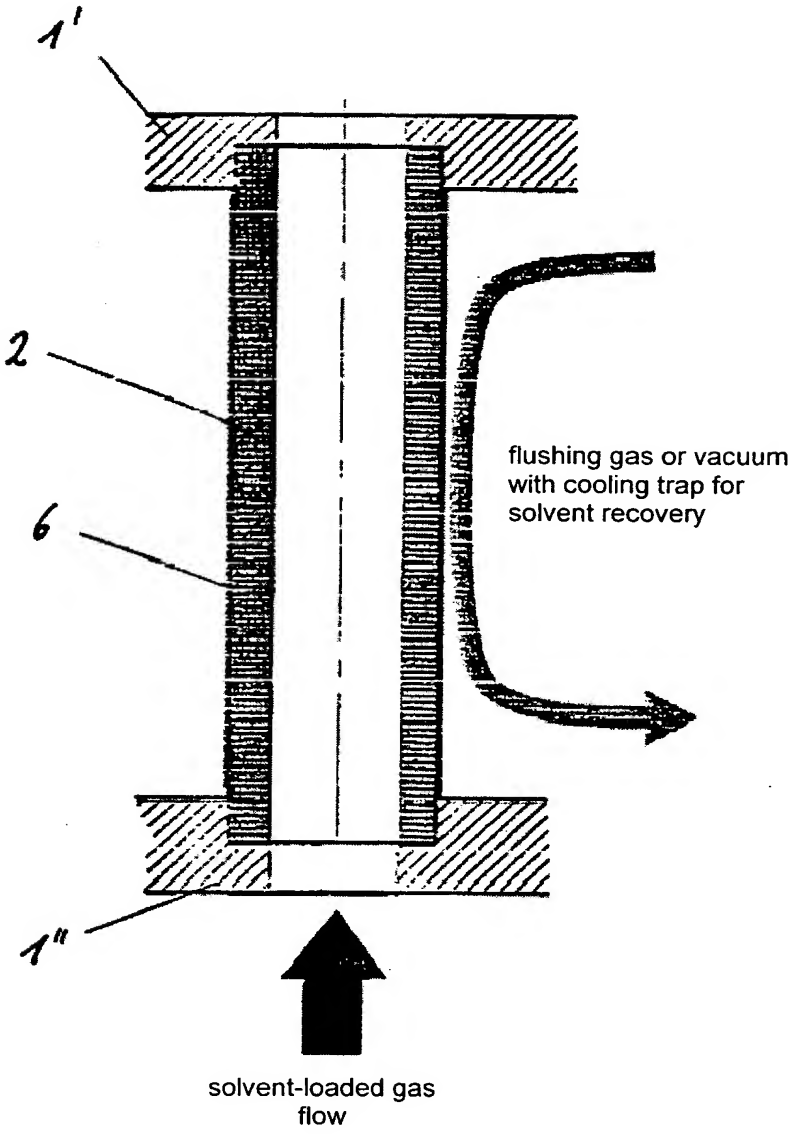

Fig. 4